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AJIC brief report

Personal protective equipment in health care: Can online infection control courses transfer knowledge and improve proper selection and use?

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We used observational evaluation to assess the ability of an online learning course to effectively transfer knowledge on personal protective equipment (PPE) selection and removal. During orientations for new hospital staff, 117 participants applied either airborne, droplet, or contact precautions in mock scenarios. Postcourse, all 3 scenarios demonstrated improvement in PPE sequence scores ($P = .001$); moreover, hand hygiene also was more frequent during both donning and doffing of PPE ($P < .001$). (Am J Infect Control 2008;36:e33-e37.)

The use of personal protective equipment (PPE) is required in health care settings to protect health care workers (HCWs). The choice of PPE is dictated by the route of transmission of the putative agent as well as by the clinical situation and may consist of a combination of gloves, gown, eye and/or facial protection (EFP), and mask or N95 respirator. The appropriate PPE items must be selected, and the items must be put on and removed in the correct sequence to minimize the risk of exposure. This principle was illustrated during the severe acute respiratory syndrome (SARS) epidemic in 2003 when some HCW infections possibly resulted from the improper use of PPE.[1,2]

Through the use of consistent messages, images, and videos, online training has the potential to instruct HCWs about PPE in a standardized and accessible manner.[3-6] Studies show that online training courses are as effective as traditional teaching methods.[3-6] Although PPE use has been researched,[7-12] how well online training imparts this knowledge to HCWs has not been widely evaluated.

The present study evaluated PPE selection and use by HCWs through observational analysis, both before and after the HCWs took an online infection control course.

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METHODS

All new staff members at Vancouver General Hospital and its affiliated long-term care and rehabilitation facilities are required to take a 30-minute online infection control course as part of a 4-day orientation program. The course uses graphics, videos, and text to teach the principles of infection control, hand hygiene (HH), and PPE use.[13] To assess whether or not the course actually improves PPE selection and use by HCWs, observational analysis was used to assess the transfer of learning from the course to the HCWs' behavior.[14-17] From March to June 2007, nurses, care aides, and allied health staff attending the orientation program were invited to participate in a structured observation of PPE use before and after taking the infection control course. A total of 145 HCWs were recruited (100% of all orientation program attendees), but only 117 complete observations precourse and postcourse were collected. All of the HCWs provided informed consent before participation.

Clinical scenarios

In the hospital setting, patients are placed under airborne, droplet, or contact isolation precautions,

Table 1. PPE selection scores by experience, isolation precautions scenario, and risk level

Analysis	High-/low-risk points against	Value of correct score	n	Precoursemean (SD)	Postcoursemean (SD)	*P* value
Overall average	NA	NA	117	1.35 (1.32)	1.11 (1.20)	.043
Experience, years						
Less than 1	NA	NA	64	1.58 (1.40)	1.17 (1.21)	.016
At least 1	NA	NA	53	1.09 (1.18)	1.04 (1.19)	.751
Airborne precautions*			37			
High risk	2	0		0.43 (0.83)	0.16 (0.55)	.058
Low risk	3	0		2.08 (0.68)	2.00 (1.10)	.674
Droplet precautions†			39			
High risk	4	0		0.97 (1.20)	0.41 (0.81)	.014
Low risk	2	0		0.17 (0.50)	0.15 (0.48)	.822
Contact precautions‡			41			
High risk	4	0		0.00 (0.00)	0.04 (0.31)	.323
Low risk	2	0		0.51 (0.63)	0.63 (0.66)	.200

NA, not applicable.

*Airborne precautions selection: Two points against for high-risk selection: either surgical mask (2) or no mask whatsoever (2). Three points against for low-risk selection: using eye/face protection (1), gown (1), or gloves (1) (overprotection).

†Droplet precautions selection: Four points against for high-risk selection: no eye and face protection (2) or no mask (either surgical mask or N95 respirator) (2). Two points against for low-risk selection: either no gown (1) or no gloves (1).

‡Contact precautions selection: Four points against for high-risk selection: no gloves (2) or no gown (2). Two points against for low-risk selection: using eye and face protection (1) or mask (surgical mask or N95 respirator) (1).

depending on the mode of transmission of the putative agent. Three scenarios were created, each requiring the application of 1 of these 3 precautions and based on the course-embedded videos demonstrating PPE use (based on health care guidelines).[18-21] The scenarios reflected typical events in health care and were designed to initiate the minimally required steps in using PPE. The ratio of observers to participants was 1:1. The observer randomly selected a clinical scenario. Then the participant was oriented to a mock patient room; the scenario was read aloud; the specific precaution was stipulated; and the participant was instructed to select, put on (don), and take off (doff) the appropriate PPE. Immediately after completing the infection control course, the participant was provided with the same scenario and given the same instructions.

Observers

The observer team was composed of professionals in occupational health, infection control, patient safety, and education. Interobserver variability was minimized with prepared scripts and a standardized form outlining the accepted PPE use for each scenario. To ensure consistency, the observers were trained in groups in all scenarios. Observers were supervised onsite, and all observations were recorded on the standard form.

Sample size, scoring, and statistical analysis

Thirty participants per scenario were required to achieve a predetermined significance level of $< .05$; therefore, a target number of 40 participants per scenario was set. The observation forms were scored twice, once for PPE selection and once for the donning and doffing sequence. For PPE selection, a participant scored ''0'' if no errors were made; points were allotted for each error. Errors were classified as high or low risk (to HCWs and patients alike), with weighting based on established infection control principles.[18-20,22] For the PPE sequence evaluation, the participant was given a ''1 point, 1 task'' score based on the observed structured clinical examination method, with a total maximum score based on the number of donning and doffing and hand hygiene tasks performed.[23,24]

The participant's precourse and postcourse scores were compared using paired *t*-tests, with comparative analyses computed collectively and for each of the 3 scenarios. Analyses were done using SPSS for Windows version 14.0 (SPSS Inc, Chicago, IL).

HH guidelines recommend a certain frequency of hand cleaning, depending on the type of isolation precaution.[18,19,25,26] In these observations, the participant's use of the prescribed HH opportunities for each scenario was recorded. The HH score was calculated by multiplying the number of HH opportunities by the number of subjects in each scenario. The total HH score was compared with the maximum possible score. Percentages of the total score were compared using the χ^2 test.

RESULTS

Precourse and postcourse paired observations were fully completed by 117 participants (airborne precautions, n = 37; droplet precautions, n = 39; contact

Table 2. PPE sequence scores by experience and isolation precaution scenario

Analysis	n	Maximum possible score	Precourse mean (SD)	Postcourse mean (SD)	*P* value
Overall average	117	NA	4.61 (1.87)	6.52 (2.28)	<.001
Experience, years					
Less than 1	64	NA	4.51 (1.95)	6.59 (2.24)	<.001
At least 1	53	NA	4.76 (1.78)	6.46 (2.36)	<.001
Airborne precautions sequence*	37	7	3.19 (1.55)	4.97 (1.62)	<.001
Droplet precautions sequence†	39	13	6.07 (1.62)	8.87 (2.05)	<.001
Contact precautions sequence‡	41	6	4.51 (1.24)	5.70 (0.64)	<.001

NA, not applicable.

*Seven steps in the airborne precautions sequence.

Donning: (1) Perform hand hygiene. (2) Put on N95 respirator. (3) Do a fit check of N95 for face seal. Doffing: (1) Exit the patient's room. (2) Perform hand hygiene. (3) Remove N95 respirator. (4) Perform hand hygiene.

†Thirteen steps in the droplet precautions sequence.

Donning: (1) Perform hand hygiene. (2) Put on mask (either surgical or N95 respirator). (3) Put on eye and face protection. (4) Put on gown. (5) Put on gloves. Doffing: (1) Remove gloves. (2) Remove gown. (3) Perform hand hygiene. (4) Exit patient's room. (5) Take off eye and face protection. (6) Perform hand hygiene. (7) Remove mask. (8) Perform hand hygiene.

‡Six steps in the contact precautions sequence.

Doffing: (1) Perform hand hygiene. (2) Put on gown. (3) Put on gloves. Donning: (1) Take off gloves. (2) Take off gown. (3) Perform hand hygiene.

precautions, n = 41). Most of the participants (81.2%) were nurses; the others were care aides and licensed practical nurses (12%) and allied health personnel (6.8%). Nearly 55% of the participants had less than 1 year of experience in their current profession.

Selection

A statistically significant improvement in scores postcourse ($P = .043$) was observed overall when proper selection of PPE was reviewed. This improvement was attributed largely to improved selection of PPE for the droplet precautions clinical scenario (Table 1). Interestingly, as a group, the participants with less than 1 year of experience demonstrated more improvement postcourse (n = 64; $P = .016$) than the more seasoned HCW group (n = 53; $P = .751$) (Table 1). Thirty-two participants achieved a perfect precourse and postcourse selection score (droplet precautions, n = 15; contact precautions, n = 17; airborne precautions, n = 0). When the perfect scores were removed, the analysis still revealed a statistically significant improvement in scores postcourse (n = 85; $P = .043$). No differences in scores were found based on occupation or type of medical service.

Sequence

Analysis of the proper sequence of PPE use revealed a statistically significant improvement ($P < .001$) for the overall score, postcourse score, and each of the 3 clinical scenarios (Table 2). No participant had a perfect sequence score either precourse or postcourse. Both the separate donning and doffing sequence scores exhibited a statistically significant improvement ($P < .002$) postcourse. In addition, a statistically significant improvement ($P < .001$) in scores was seen for both the HCWs with less than 1 year of experience and the more experienced HCWs.

Hand hygiene

Scores for proper frequency of HH increased significantly from precourse to postcourse for all scenarios (airborne precautions, $P = .001$; droplet precautions, $P = .018$; contact precautions, $P = .004$) (Table 3).

DISCUSSION

The greatest improvement in PPE selection was seen in the droplet precautions scenario, arguably the most complex clinical scenario for HCWs. Scores for PPE selection in the airborne precautions scenario were not dramatically improved postcourse. As a result, the course has since been revised to include itemized lists of PPE for the different types of precautions and ''drag-and-drop'' exercises for PPE selection and donning/doffing sequences to immediately reinforce lessons learned.

Overall improvement in PPE selection for all clinical scenarios was found in HCWs with less than 1 year of experience. This suggests that the novice workers may be especially amenable to targeted training in PPE selection and use, particularly given their requirements for immediate workplace training. As part of a larger infection control education program, accessible, standardized online learning appears to be suitable in meeting this need.

Experience during the SARS outbreak and subsequent studies have highlighted the need for careful sequential removal of PPE.[1,2,7-12] Thus, it was reassuring to find a statistically significant improvement

Table 3. Hand hygiene sequence scores by hand hygiene opportunities

	Donning sequence				Doffing sequence			
Scenario	**Maximum possible score**	**Precourse score (%)**	**Postcourse score (%)**	***P* value**	**Maximum possible score**	**Precourse score (%)**	**Postcourse score (%)**	***P* value**
Airborne	37	26 (70.3)	31 (83.8)	.167	74	39 (52.7)	58 (78.4)	.001
Droplet	39	30 (76.9)	36 (92.3)	.060	117	42 (35.9)	60 (51.3)	.018
Contact	41	21 (51.2)	35 (85.4)	.001	41	31 (75.6)	40 (97.6)	.004
Total	117	77 (65.8)	102 (87.2)	.001	232	112 (48.3)	158 (68.1)	.001

in both donning and doffing of PPE for all clinical scenarios regardless of HCW experience level. It is likely that although correct selection of PPE was emphasized in HCW training previously, less attention was given to the sequence of removal, thus accounting for the general improvement regardless of experience level.

The improvement seen in HH compliance was greater than that reported by other researchers. Harbarth et al[25] reported an average HH compliance of only 34%, and Golan et al[26] reported compliance of only 10% before care and 36% after care. We found average postcourse HH compliance scores of 87% when donning PPE and 68% when doffing PPE. A possible Hawthorne effect cannot be ruled out; however, the initial low scores (despite being observed), followed by the improvement postcourse suggest that the course increased the participants' awareness of the need for HH. This is noteworthy given the critical role of proper and frequent HH in minimizing hospital-acquired infections.

CONCLUSION

Here we took a novel approach to studying PPE knowledge transfer by (1) embedding a study into an educational program already in session, (2) creating a realistic validation system for observing and scoring tasks, and (3) measuring the two elements of PPE practice—selection and sequence—separately. Our findings indicate that online infection control courses are able to adequately transfer knowledge regarding appropriate PPE selection and use. This method of delivery could improve an organization's capacity to provide standardized and accessible infection control training. Further studies are needed to verify that knowledge transfer is retained over time and that proper infection control practices are maintained in actual clinical settings.

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